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EXPERIMENTAL INVESTIGATION ON PROPERTIES OF SURFACE RADIATION OF SOLAR COLLECTOR RECEIVER TUBE MATERIAL WITH BLACK NICKEL COATING

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ABSTRACT

In this study, the characteristics of surface radiation heat transfer properties of stainless steel 304with Black Nickel coating is investigated with and without exposure of sunlight to measure the emissivity (€) and absorptivity (à). Exposure of sunlight is carried out for various time internals (240, 480, 720 and 960 hrs). For every 10 equal intervals, the material is measured for temperature dependency property. The emissivity (€) and absorptivity (à) is measured for various spray distance (30, 35 and 40mm) of coating. It is observed that emissivity of the material is decreasing and absorptivity of the material is increasing with exposure time. The combined effect of decrease in emissivity and increase in absorptivity leads to which the rate of radiation loss for exposed surface with compared to unexposed surface is decreasing with black nickel coating at an optimum spray distance of 35mm.

KEYWORDS: Absorptivity & Emissivity

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Original Article

INTRODUCTION

The study of degradation characteristics of stainless steel 304 was carried out by G. Mageshwaran et al. under various time interval and temperature variation, by which, there is a reduction in aS/E ratio which increases emissivity and decreases absorptivity [1]. The degradation property of surface radiation is carried out on black chrome-coated stainless substrates by using electron spectroscopy [2]. The operating variables such as humidity and adhesion have a major effect on the surface radiation and optical property [3]. The relation on temperature absorptivity and wavelength reflectivity is studied and the behaviour of material with iron oxide coating is studied [4]. The material characteristics of absorber and direct conversion of sunlight to electricity in a tower receiver is studied [5]. The property of black-copper-coated mild steel is investigated, and it is characterised as temperature increases with heat loss with an inversion curve between temperature efficiency relation for a mass flow rate of 0.011kg/s [6]. The study is carried out for the various optical properties for various materials with uncoated and unexposed surfaces and its relation between temperature and wavelength is discussed [8]. The performance of collector is compared between therminol oil and water for the optical efficiency of tubular receiver and hybrid receiver, and concluded that therminol oil has a high rate of performance as collector [9]. The optical efficiency changes with exposure to sunlight and optimised parameters for surface are studied and to calculate efficiency, analytical method is used [10]. The selection of optimum cutting process and cutting machine is carried out [11].

EXPERIMENTAL SETUP

The stainless steel plate is readily available in the market without any dimension, in which, it is cut into the required shape and size Figure 2a and Figure 2b. The cutting process and cutting machine for machining of stainless steel plate is selected from [11]. The material is cut into two pieces, one is for exposing sunlight and another is for unexposed sunlight, both the materials are subjected into coating using black nickel. The exposing material is further cut into required shape and test such as emissivity and absorptivity, carried out by testing machine.

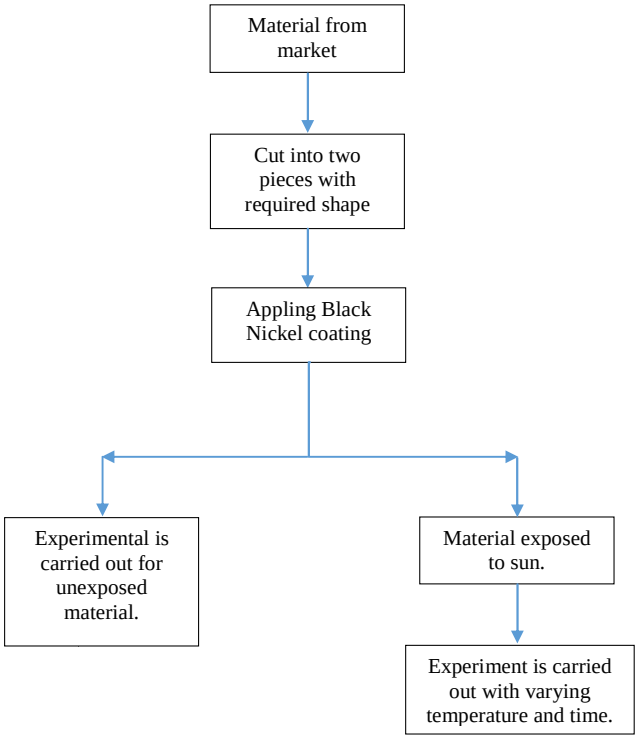

Figure 1: Block Diagram of Experimental Setup

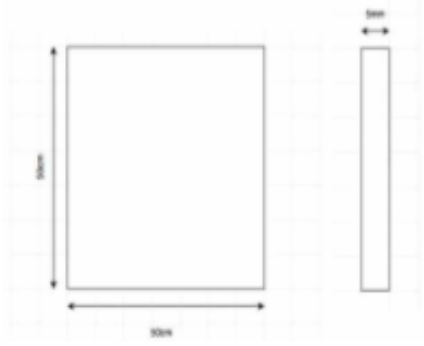

Figure 2a: Line Diagram of Plate

Figure 2b: Square Plate

RESULTS AND DISCUSSIONS

Emissivity and Absorptivity of SS Unexposed to Sunlight

The experiment carried out to measure emissivity and absorptivity with varying temperature and spray distance without exposing to sunlight is given in Figure 3a and Figure 3b.

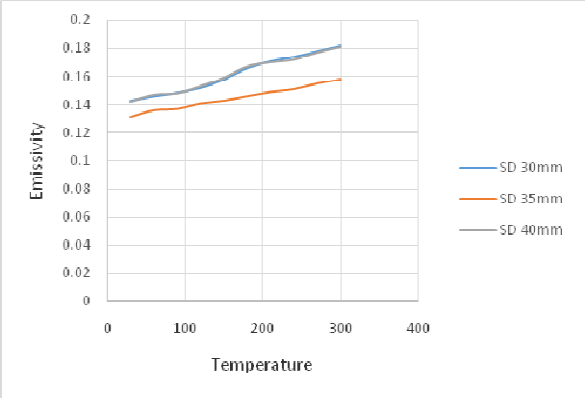

Figure 3a: Temperature Vs. Emissivity

From Figure 3a, the emissivity increases with increases with temperature, but the performance factor considered is spray distance (SD), as for SD 30 and 40 mm, emissivity is so similar but at SD 35mm, the emissivity is decreasing compared with the other two spray distances.

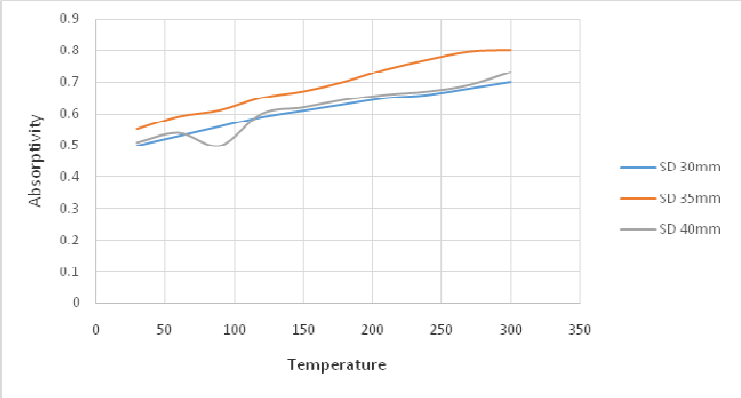

Figure 3b: Temperature Vs. Absorptivity

The absorptivity of coated SS material is increasing with increasing temperature, but absorptivity is high for the spray distance of SD 35mm as compared with other two spray distances. From Figure 3a and 3b, the emissivity of coated material is decreasing and absorptivity of coated material is increasing, but in comparing with spray distance SD 30, 35 and 40mm, the spray distance 35mm shows better results as compared with other two spray distances, in which the rate of heat transfer is increased at SD 35mm.

Emissivity and Absorptivity of SS Exposed to Sunlight

Emissivity and absorptivity of SS exposed to sunlight is carried out with varying time and temperature at three spray distance of 30, 35 and 40 mm.

Emissivity of SS Exposed to Sunlight

The emissivity of black nickel coated SS exposed to various temperature (30 to 300˚C) with varying hours (240, 480, 720 and 960 hrs) at different spray distance is shown below. The behaviour of SS material with black nickel coated has a large variation with temperature. As temperature increases, emissivity of SS with black nickel material is increases, in which, it differs with various spray distance of coating. At spray distance of 35mm, shows the best results among all other spray distances in which, the heat transfer rate of SS exposed material with spray distance 35 mm has reduced with

increase in temperature compared to another two spray distance, in which the heat transfer rate decreases. The variation of temperature and time with different spray distance for black nickel coated SS material is given below.

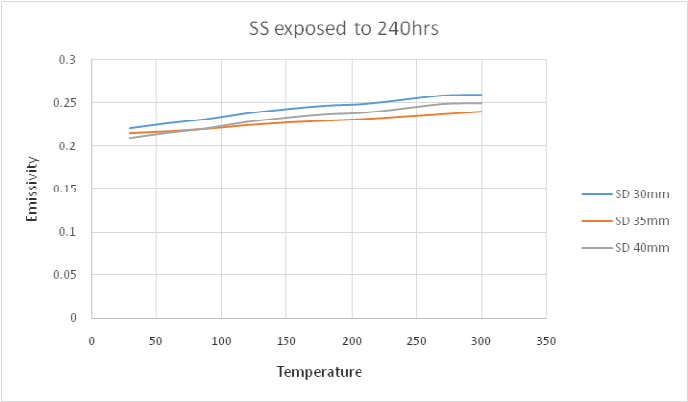

Figure 4: Temperature Vs Emissivity of SS Exposed to 240hrs

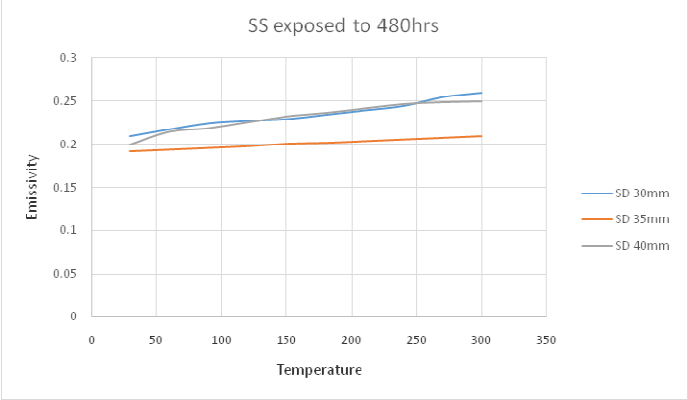

Figure 5: Temperature Vs Emissivity of SS Exposed to 480hrs

As temperature increases, emissivity also increases but with comparing to spray distance, the spray distance SD 35mm is lower for all temperature and variation of hours.

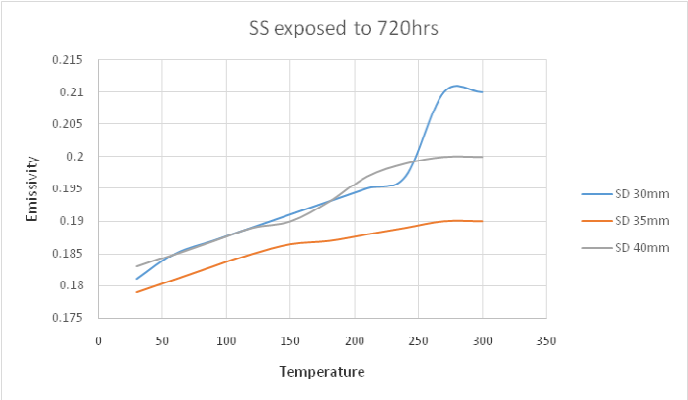

Figure 6: Temperature Vs Emissivity of SS Exposed to 720hrs

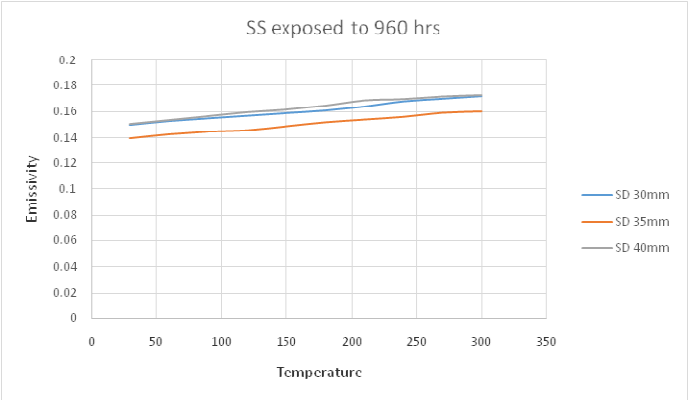

Figure 7: Temperature Vs Emissivity of SS Exposed to 960hrs

Absorptivity of SS Exposed to Sunlight

The absorptivity of black nickel coated SS exposed to various temperature (30 to 300˚C) with varying hours (240, 480, 720 and 960 hrs) at different spray distance is shown below. The behaviour of SS material with black nickel coated has a large variation with temperature and time. As temperature increases, absorptivity of SS with black nickel material increases, in which it differs with various spray distance of coating. At spray distance of 35mm, shows the best results among all other spray distances, in which the heat transfer rate of SS exposed material with spray distance 35 mm has reduced with increase in temperature compared to another two spray distance, in which the heat transfer rate decreases. The variation of temperature and time with different spray distance for black nickel coated SS material is given below.

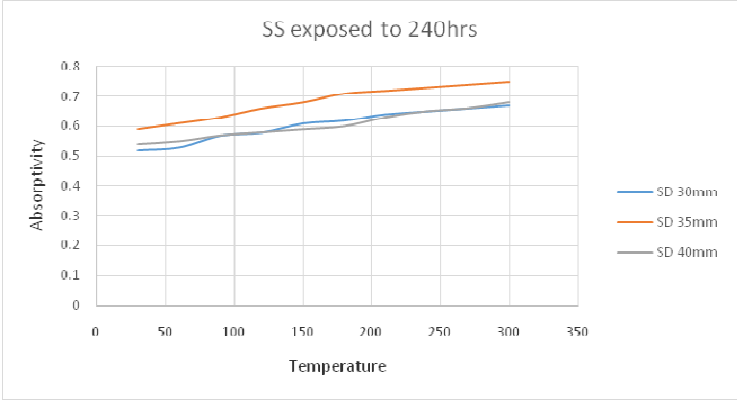

Figure 8: Absorptivity Vs Temperature of SS Exposed to 240hrs

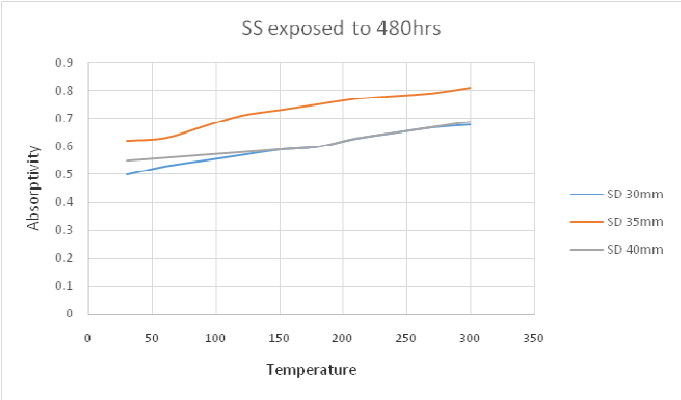

Figure 9: Absorptivity Vs Temperature of SS Exposed to 480hrs

As temperature increases, emissivity also increases, but when comparing to spray distance, the spray distance SD 35mm is higher for all temperature and variation of hours.

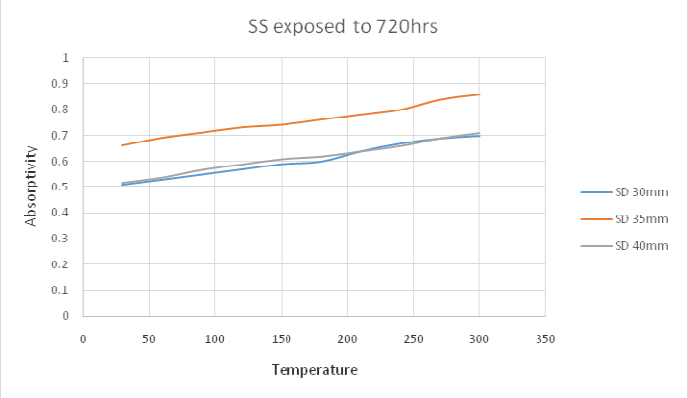

Figure 10: Absorptivity Vs Temperature of SS Exposed to 720hrs

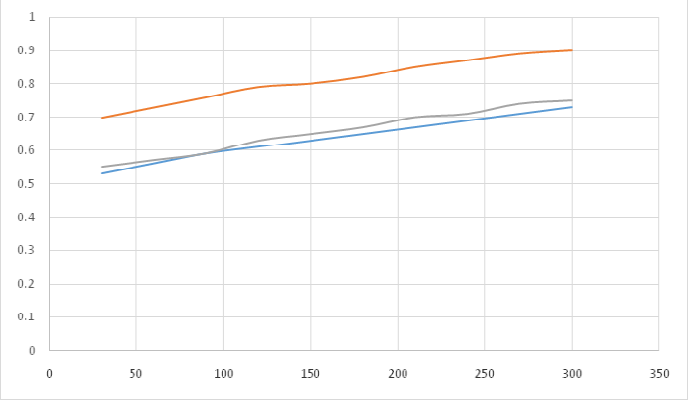

Figure 11: Absorptivity Vs Temperature of SS Exposed to 960hrs

CONCLUSIONS

Both emissivity and absorptivity of black nickel coated SS material is increasing with increase in temperature and time. But spray distance (SD 30, 35 and 40mm) plays a major parameter. At SD 35mm, the emissivity for both exposed and unexposed SS material with black nickel coating has reduced level and at the same time, absorptivity for both exposed and unexposed SS material with black nickel material coating has increased with increase in temperature and time. At spray distance of SD 35mm, has lesser emissivity and increased absorptivity, which reduces the rate of heat transfer. So, coating of black nickel on Stainless Steel material at a spray distance of 35mm will reduce heat transfer rate and also is economical.

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